MWL studies of VHE sources

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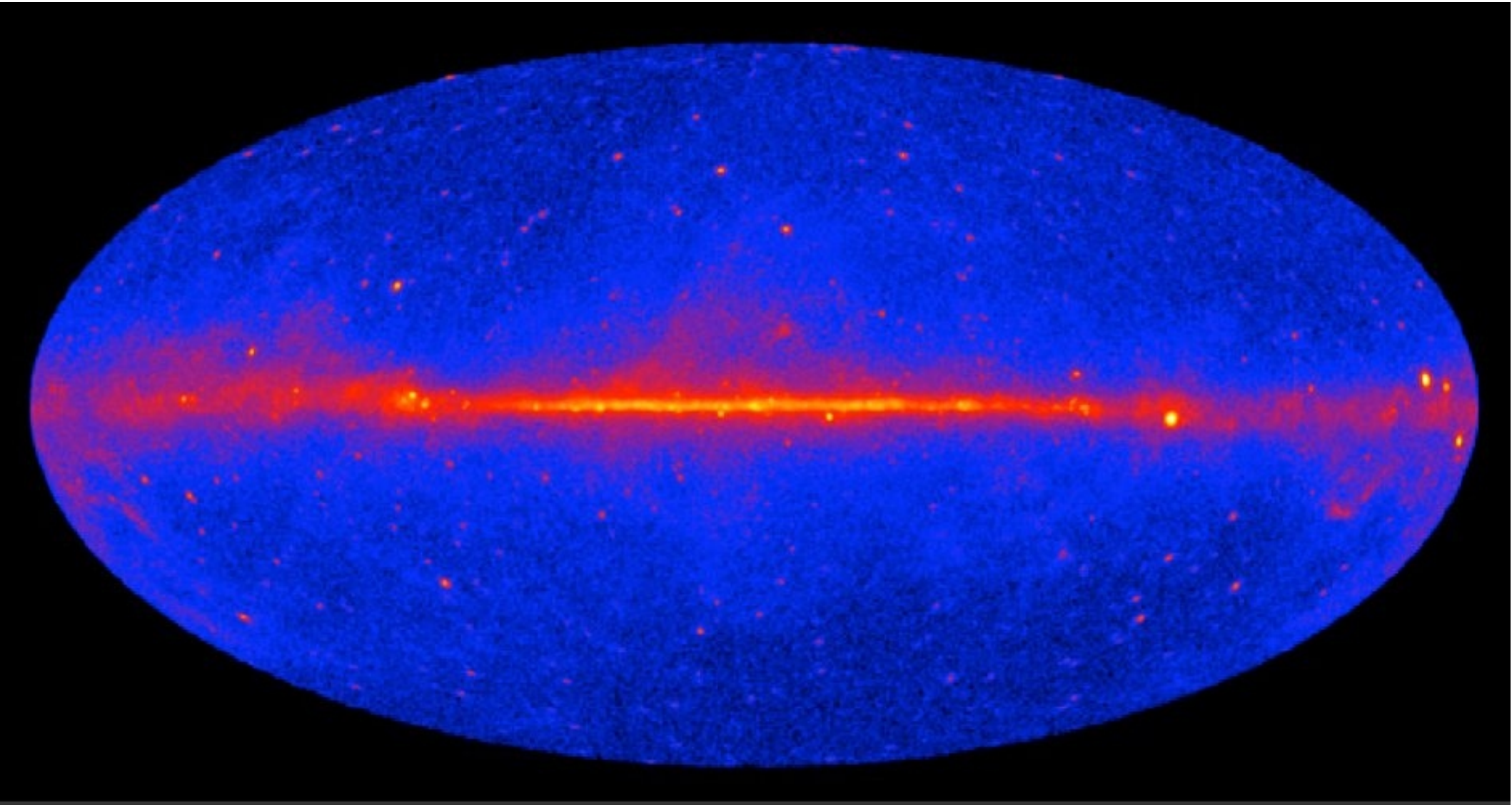
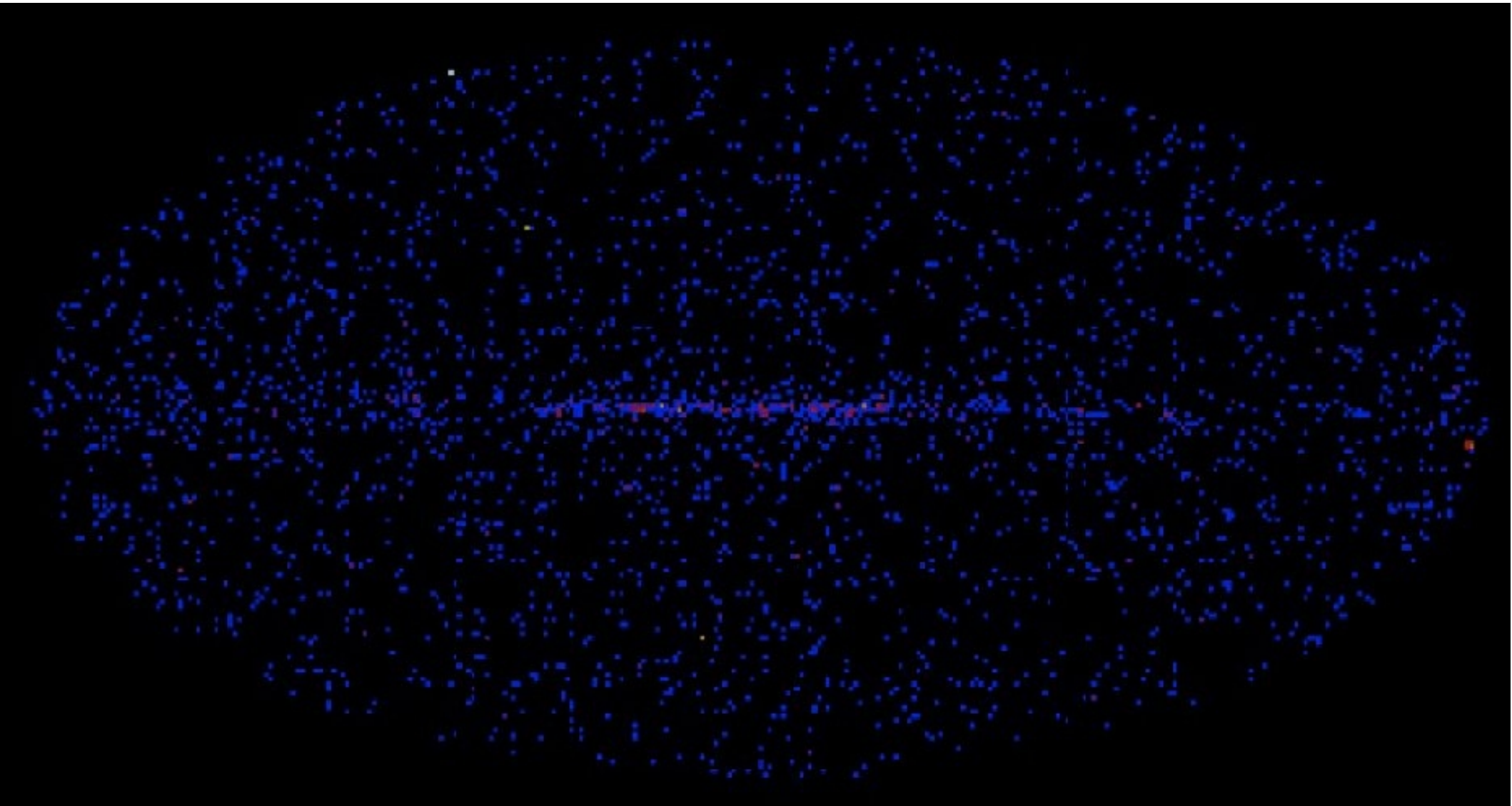
LAT and HESS survey
Association of VHE and LAT sources
MWL studies of separate classes:
SNR, PWN
Young stellar clusters,
'Dark' sources

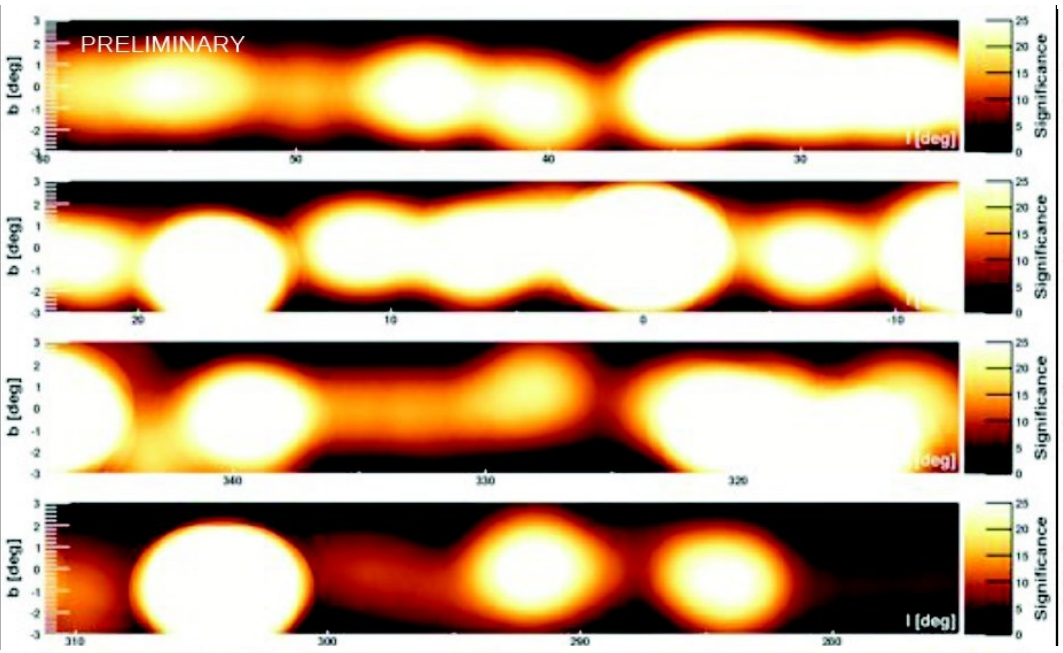
LAT survey (> 1 GeV)

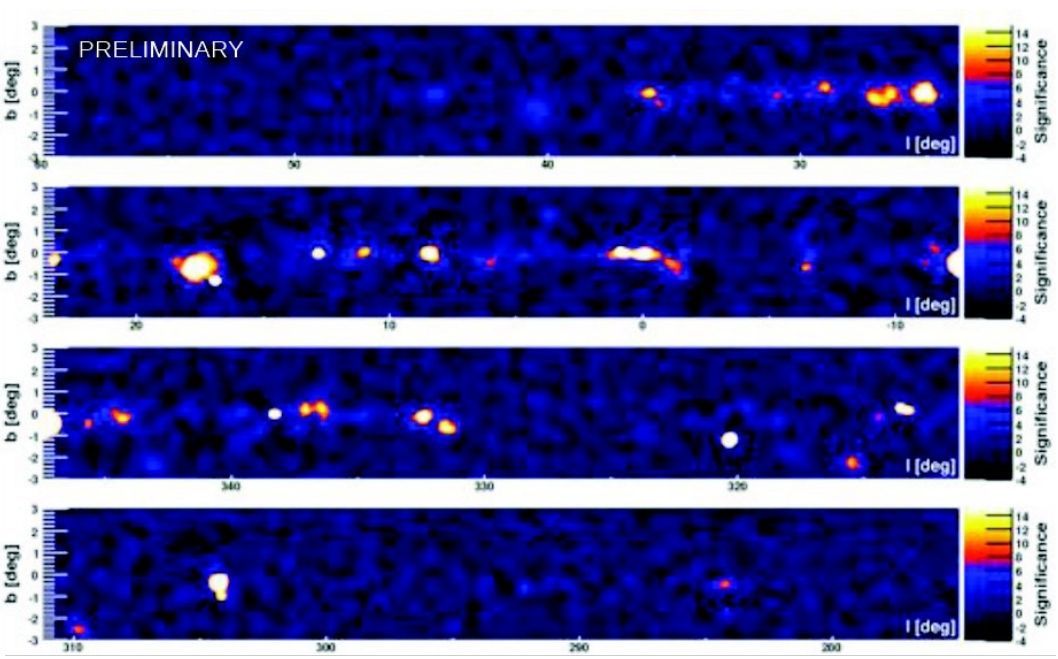


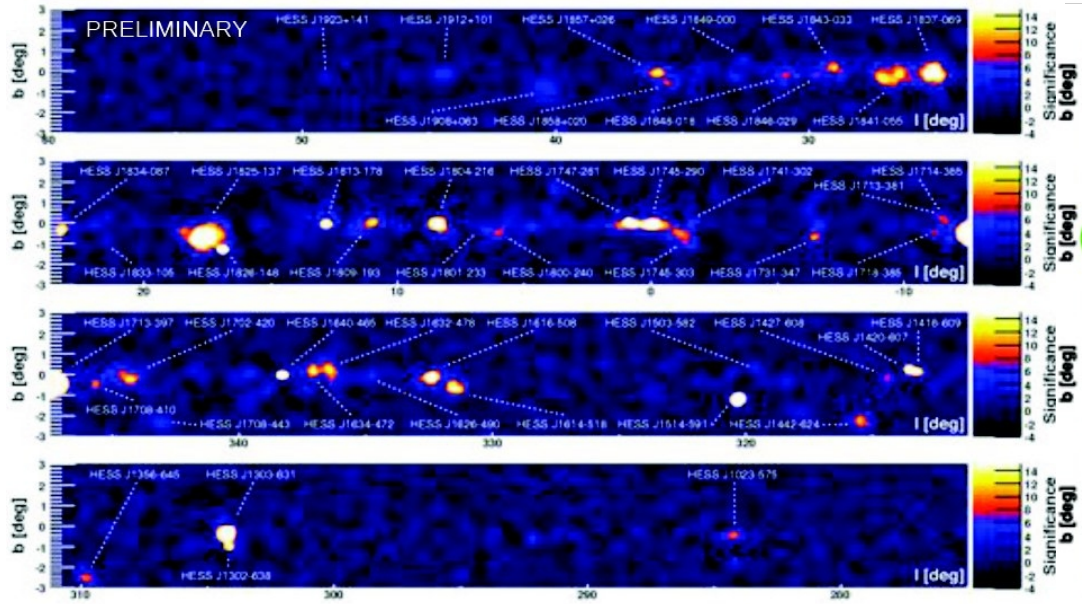
LAT survey (> 100 GeV)

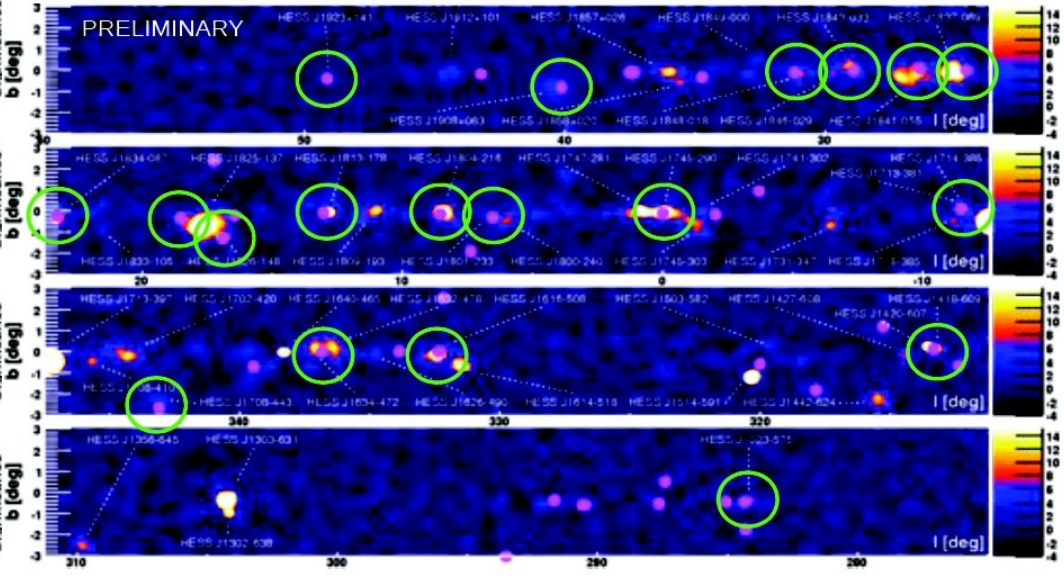


HESS Galactic Plane Survey









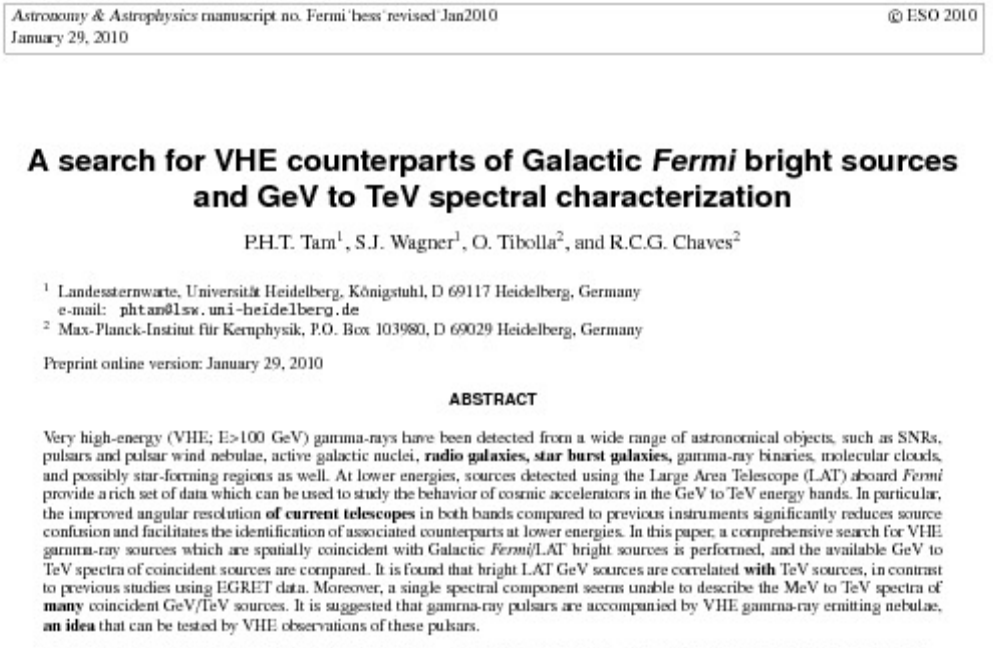
Survey associations

Tam et al. (0911.4333) studied survey associations of 0FGL- and all published VHE sources. (mostly but not only by HESS)

Overlap of VHE extension and 0FGL error box required.

Survey areas and sensitivities have not been published → statistical investigation of association not straightforward.

Conclusion : Significant spatial association of HE and VHE sources



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January 29, 2010

A search for VHE counterparts of Galactic *Fermi* bright sources and GeV to TeV spectral characterization

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ABSTRACT

Very high-energy (VHE; E>100 GeV) gamma-rays have been detected from a wide range of astronomical objects, such as SNRs, pulsars and pulsar wind nebulae, active galactic nuclei, **radio galaxies, star burst galaxies,** gamma-ray binaries, molecular clouds, and possibly star-forming regions as well. At lower energies, sources detected using the Large Area Telescope (LAT) aboard *Fermi* provide a rich set of data which can be used to study the behavior of cosmic accelerators in the GeV to TeV energy bands. In particular, the improved angular resolution **of current telescopes** in both bands compared to previous instruments significantly reduces source confusion and facilitates the identification of associated counterparts at lower energies. In this paper, a comprehensive search for VHE gamma-ray sources which are spatially coincident with Galactic *Fermi*/LAT bright sources is performed, and the available GeV to TeV spectra of coincident sources are compared. It is found that bright LAT GeV sources are correlated **with** TeV sources, in contrast to previous studies using EGRET data. Moreover, a single spectral component seems unable to describe the MeV to TeV spectra of **many** coincident GeV/TeV sources. It is suggested that gamma-ray pulsars are accompanied by VHE gamma-ray emitting nebulae, **an idea** that can be tested by VHE observations of these pulsars.

Survey associations

Tam et al. (arxiv: 0911.4333)

Table 1. 0FGL sources with spatially coincident VHE counterpart

LAT source	association[a]	class[b]	l (°)	b (°)	error[c] (°)	VHE γ-ray source	association[d]
0FGL J0534.6+2201	Crab	PSR	184.56	-5.76	0.05	HESS J0534+220	Crab nebula
0FGL J0835.4–4510	Vela	PSR	263.56	-2.77	0.04	HESS J0835–455	Vela X
0FGL J1418.8–6058		PSR	313.34	0.11	0.07	HESS J1418–609	G313.3+0.1 (Rabbit)
PSR J1420–6048		PSR	313.5	0.2	PS	HESS J1420–607	PSR J1420–6048
0FGL J1709.7–4428	PSR B1706–44	PSR	343.11	-2.68	0.05	HESS J1708–443	
PSR J1718–3825		PSR	349.0	-0.4	PS	HESS J1718-385	G313.3+0.1 (Rabbit)
0FGL J1907.5+0602		PSR	40.14	-0.82	0.08	HESS J1908+063	
0FGL J2032.2+4122		PSR	80.16	0.98	0.09	TeV J2032+4130	
0FGL J0617.4+2234		SNR/PWN	189.08	3.07	0.06	VER J0616.9+2230	IC 443
0FGL J1615.6–5049		SNR/PWN	332.35	-0.01	0.23	HESS J1616–508	PSR J1617–5055?
0FGL J1648.1–4606		SNR/PWN	339.47	-0.71	0.18	Westerlund 1 region	
0FGL J1714.7–3827		SNR/PWN	348.53	0.1	0.13	HESS J1714–385	CTB 37A
0FGL J1801.6–2327		SNR/PWN	6.54	-0.31	0.11	HESS J1801–233	W 28
0FGL J1834.4–0841		SNR/PWN	23.27	-0.22	0.1	HESS J1834–087	W 41
0FGL J1923.0+1411	W 51C[g]	SNR	49.13	-0.4	0.08	HESS J1923+141	W 51
0FGL J1024.0–5754		Unid	284.35	-0.45	0.11	HESS J1023–575	
0FGL J1805.3–2138		Unid	8.54	-0.17	0.19	HESS J1804–216	W 30/PSR J1803–2137?
0FGL J1839.0–0549		Unid	26.34	0.08	0.12	HESS J1841–055	
0FGL J1844.1–0335		Unid	28.91	-0.02	0.15	HESS J1843–033	
0FGL J1848.6–0138		Unid	31.15	-0.12	0.16	HESS J1848–018	
0FGL J0240.3+6113	LS I +61 303	HMXB	135.66	1.08	0.07	VER J0240+612	LS I +61 303
0FGL J1826.3–1451	LS 5039	HMXB	16.89	-1.32	0.11	HESS J1826–148	LS 5039

Survey associations

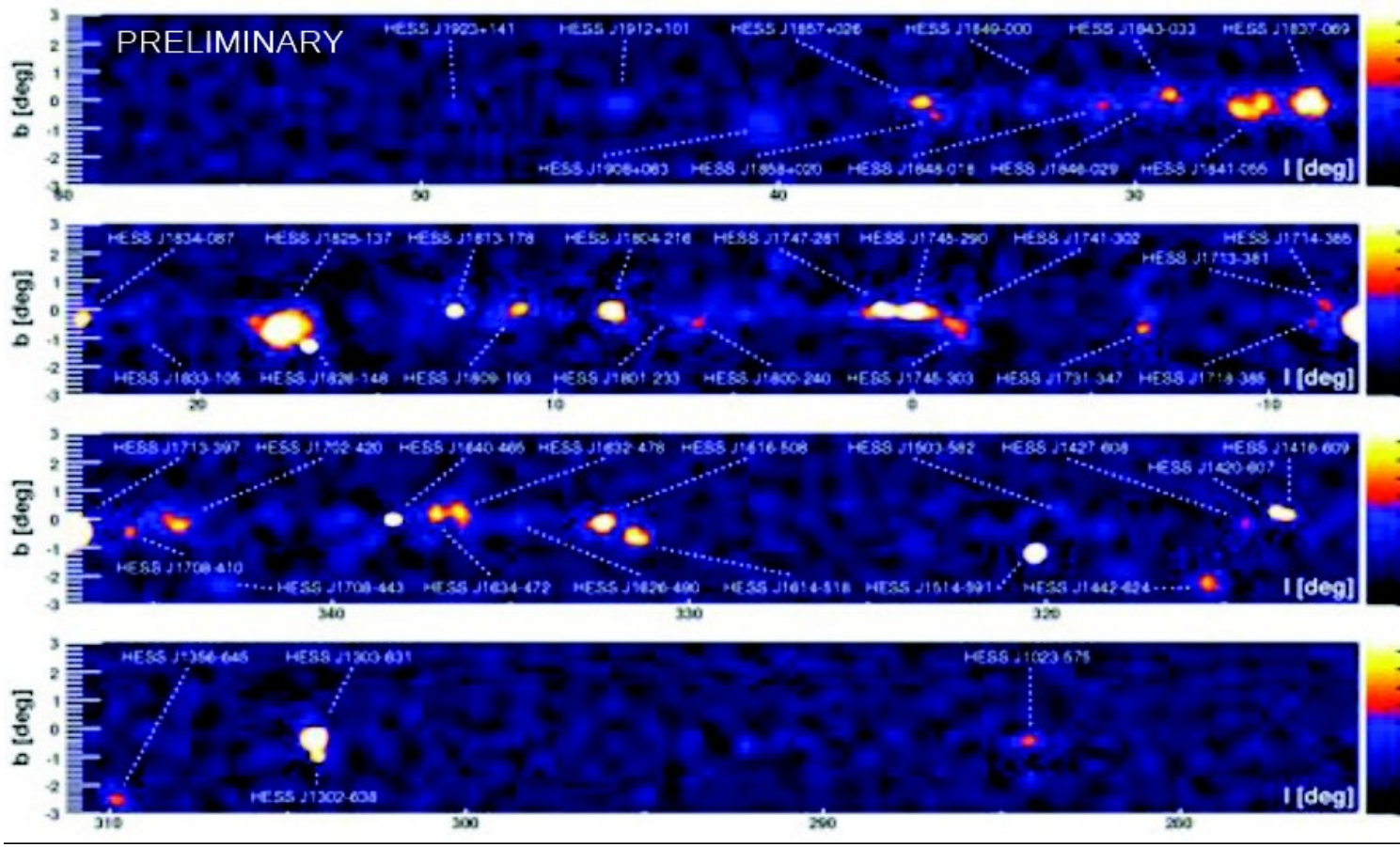
-6 LAT pulsars with VHE sources (PWNe?) [Tam et al. , Arxiv 0911.4333]
-Broad-band spectra still not conclusive on hadronic/leptonic origin.
-High rate of associations allows to weed out EG sources
-No systematic differences between source classes (sample size)
-Spectral mismatches despite spatial association, possibly due to blending and spatial mismatch

Conclusion different from Funk et al., 2008
(who had used an EGRET source list)

* not all Galactic EGRET sources were real
* more VHE sources
* LAT sources measured at higher energies
* consideration of source extension/error box

HE-VHE associations

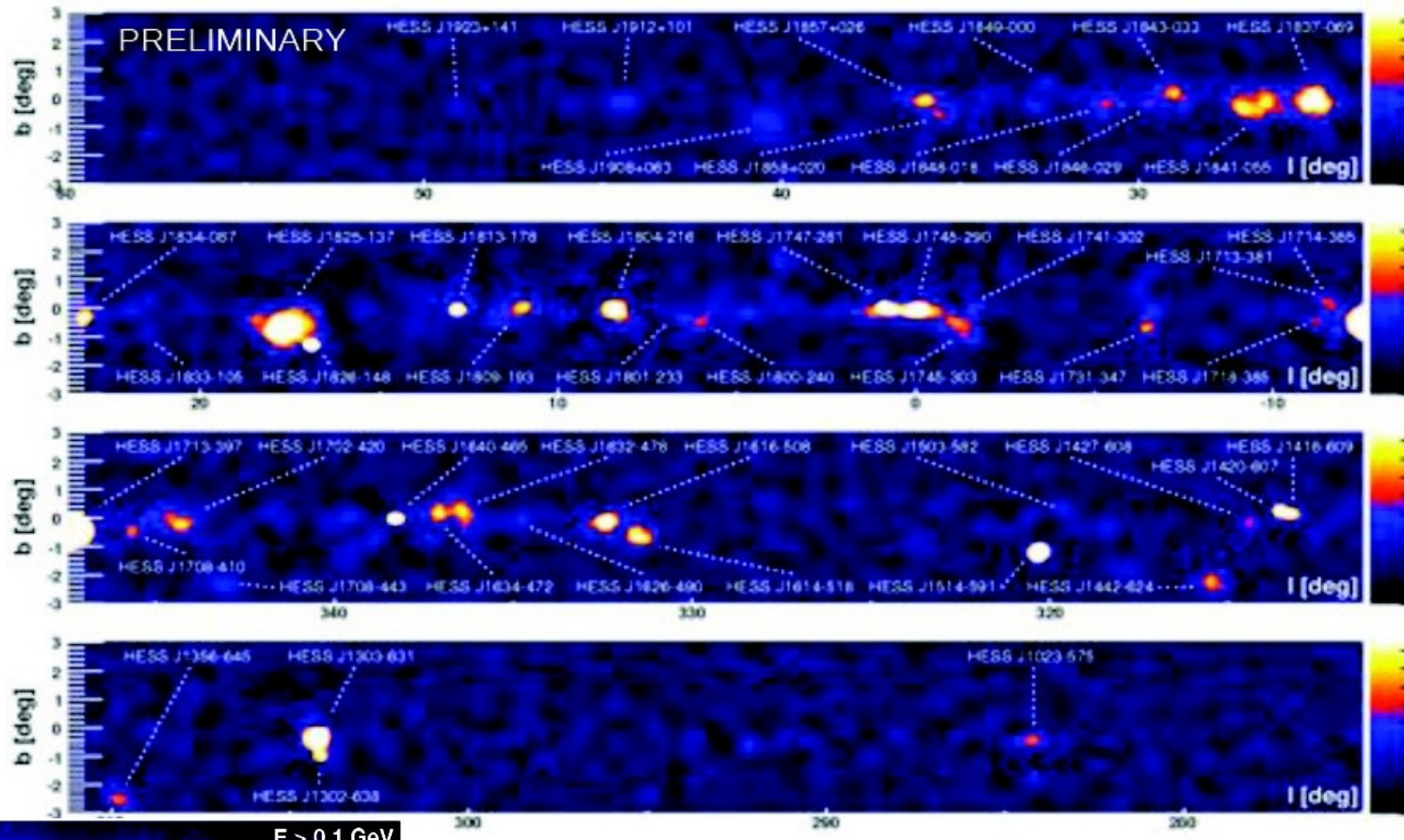
1FGL with many more Galactic GeV sources calls for repetition.

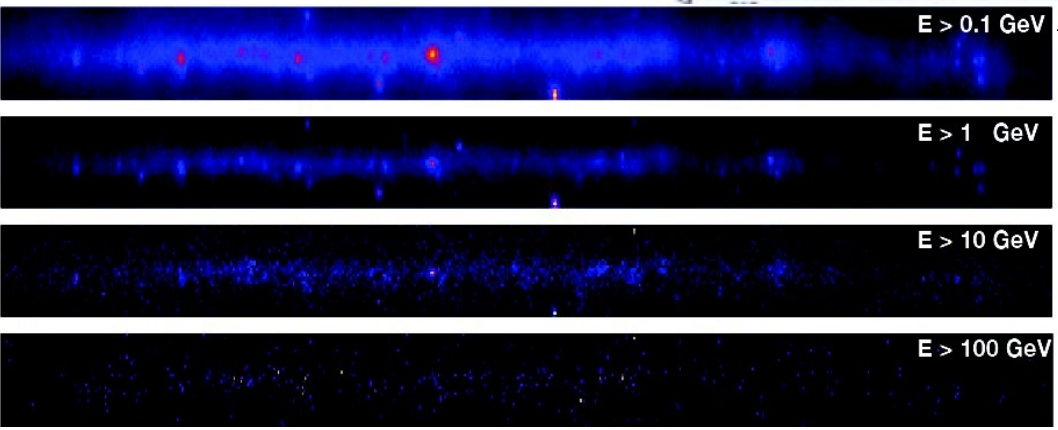


HE-VHE associations

1FGL with many more Galactic GeV sources calls for repetition.

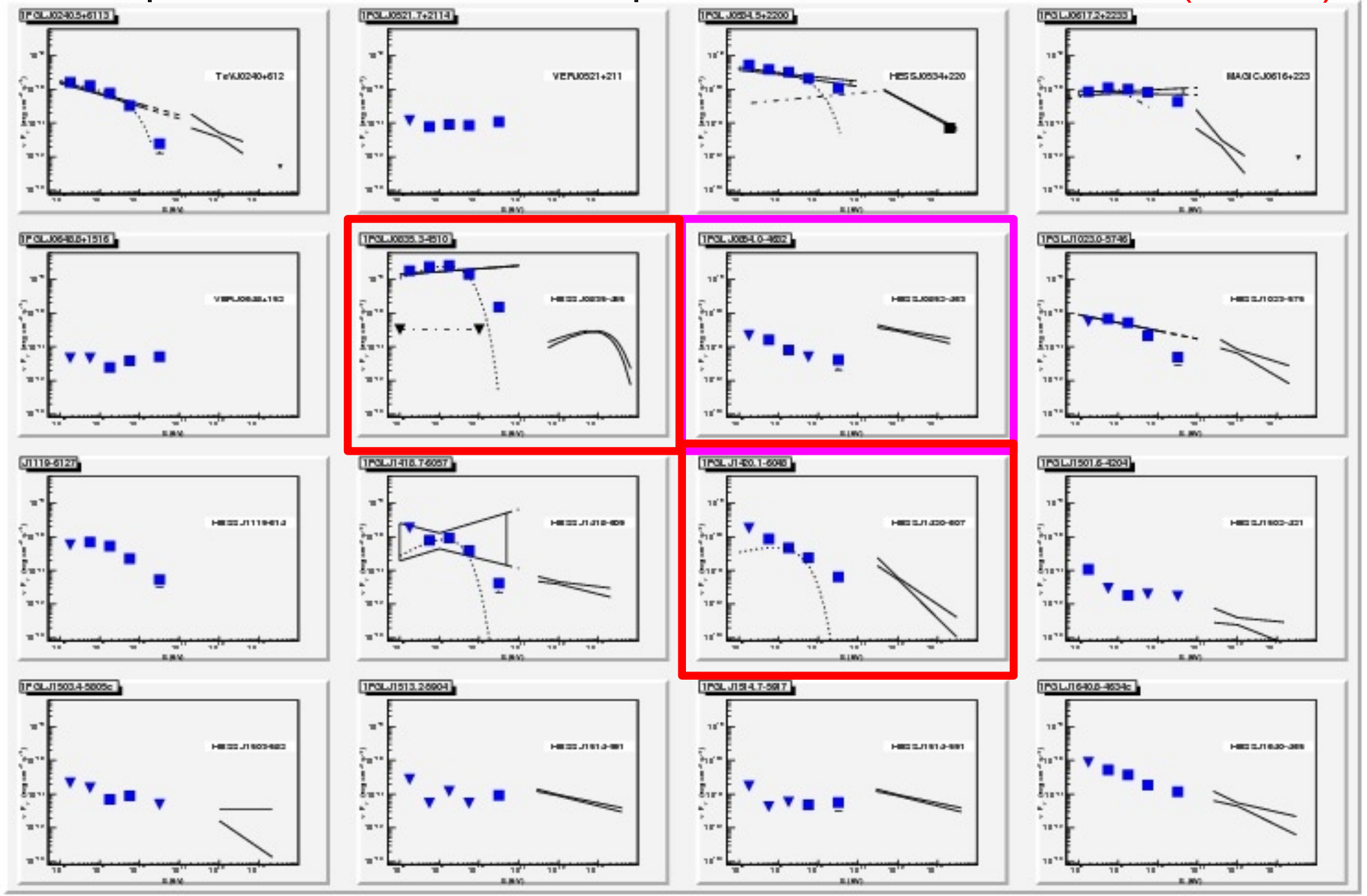
Enough statistics to determine more detailed spectra...



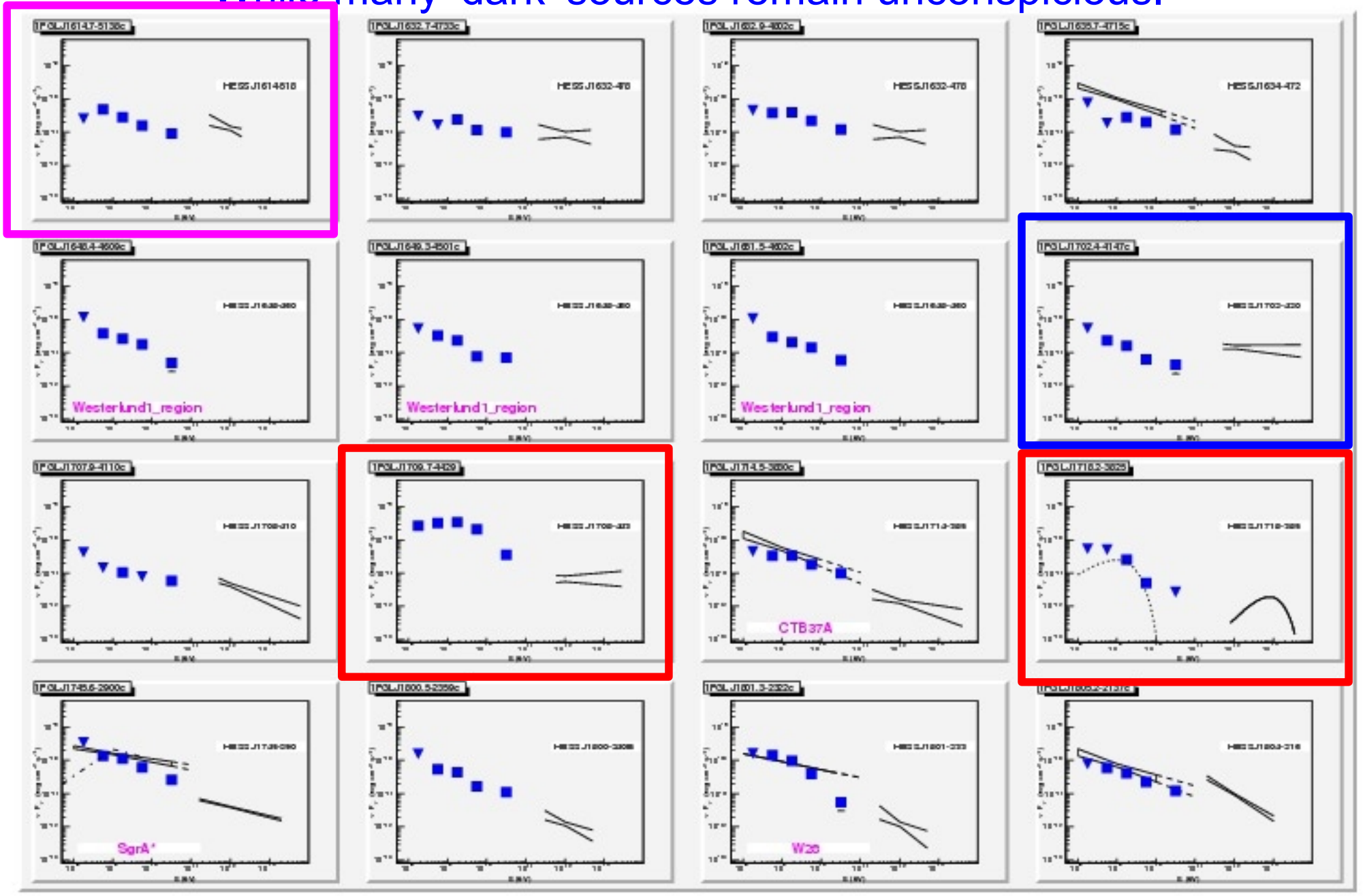


...or search for sources in individual energy bins in Fermi data

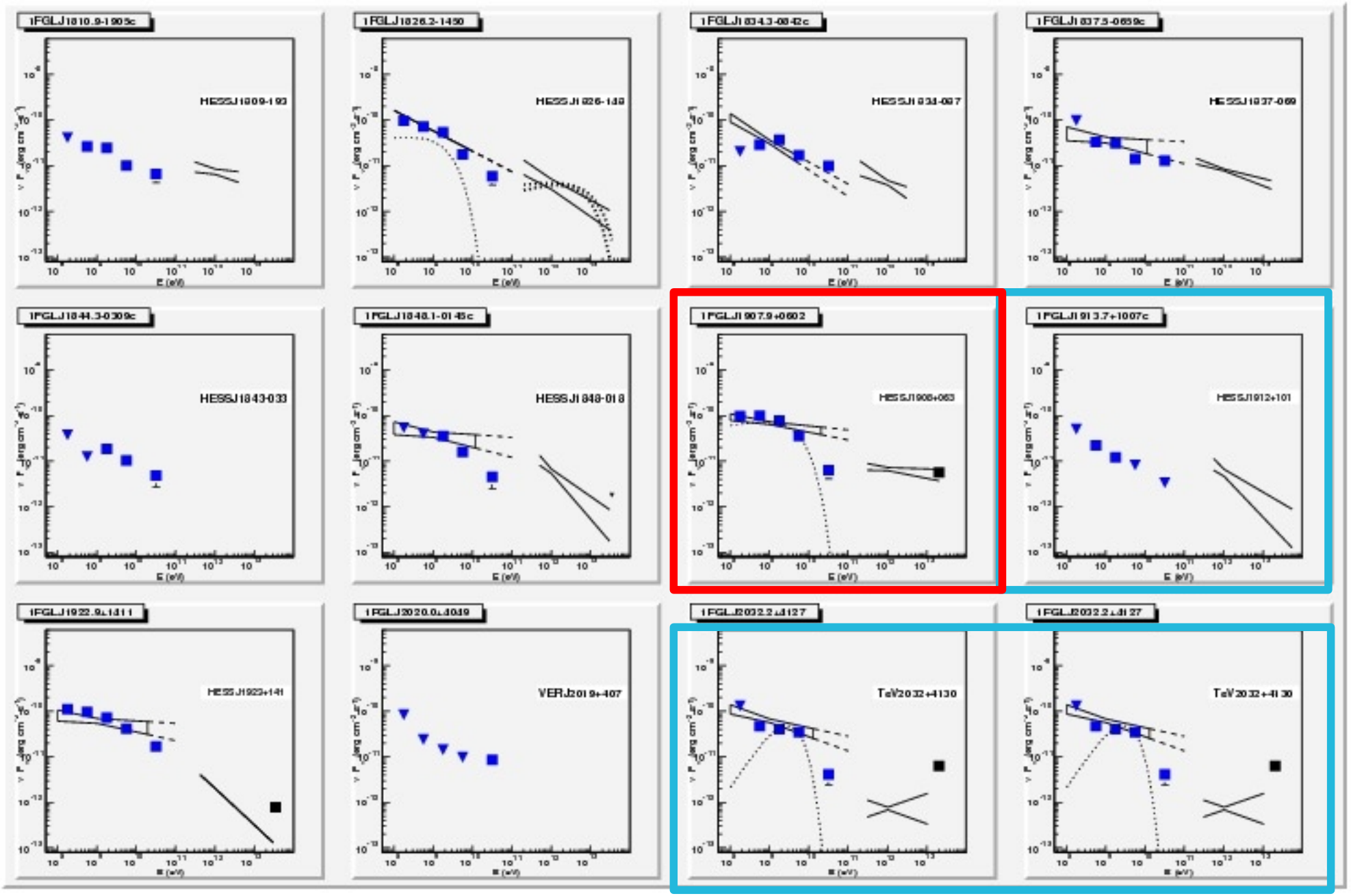
Examples of well understood spectral mismatches: Vela X (PWNe)



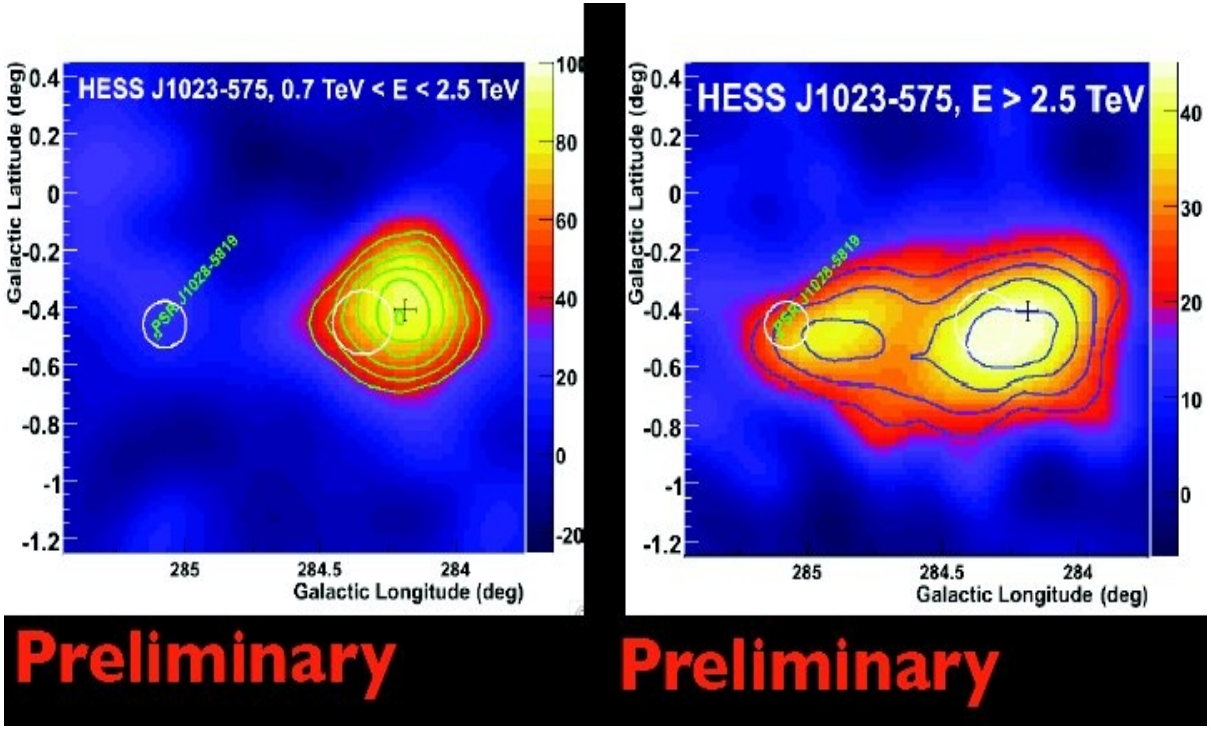
While many 'dark' sources remain unconspicious.



Source confusion and diffuse emission in LAT data



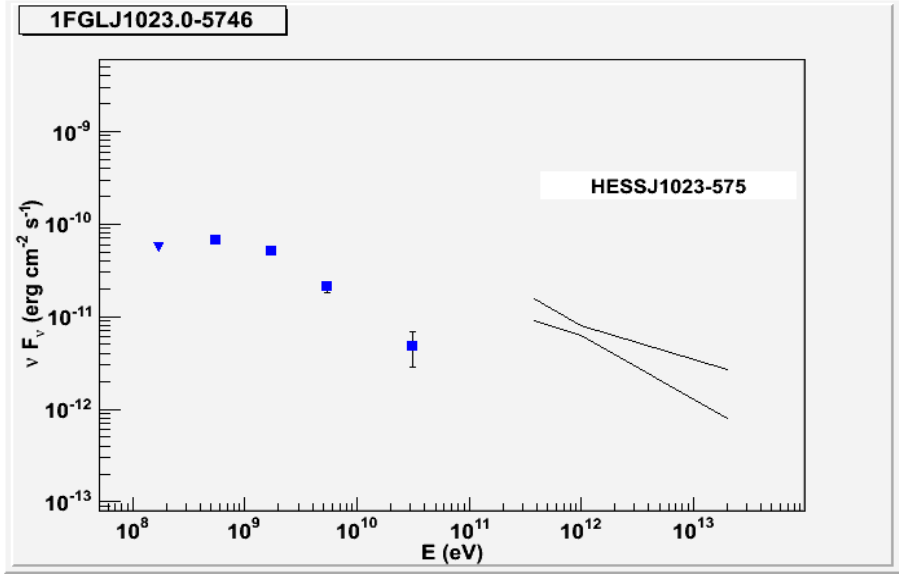
Main concern: extraction regions



Example: Westerlund 2

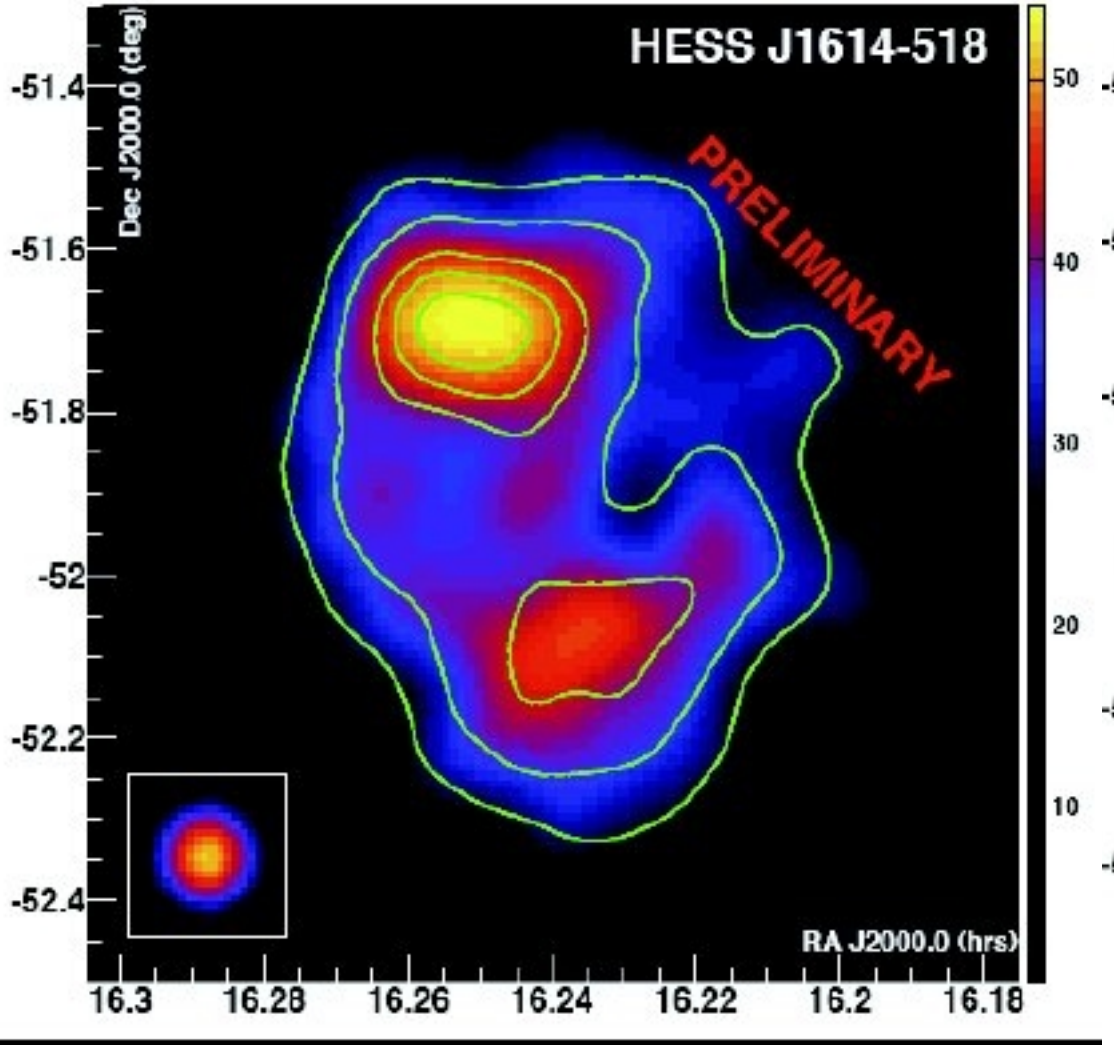
Stellar cluster
2 PWNe?

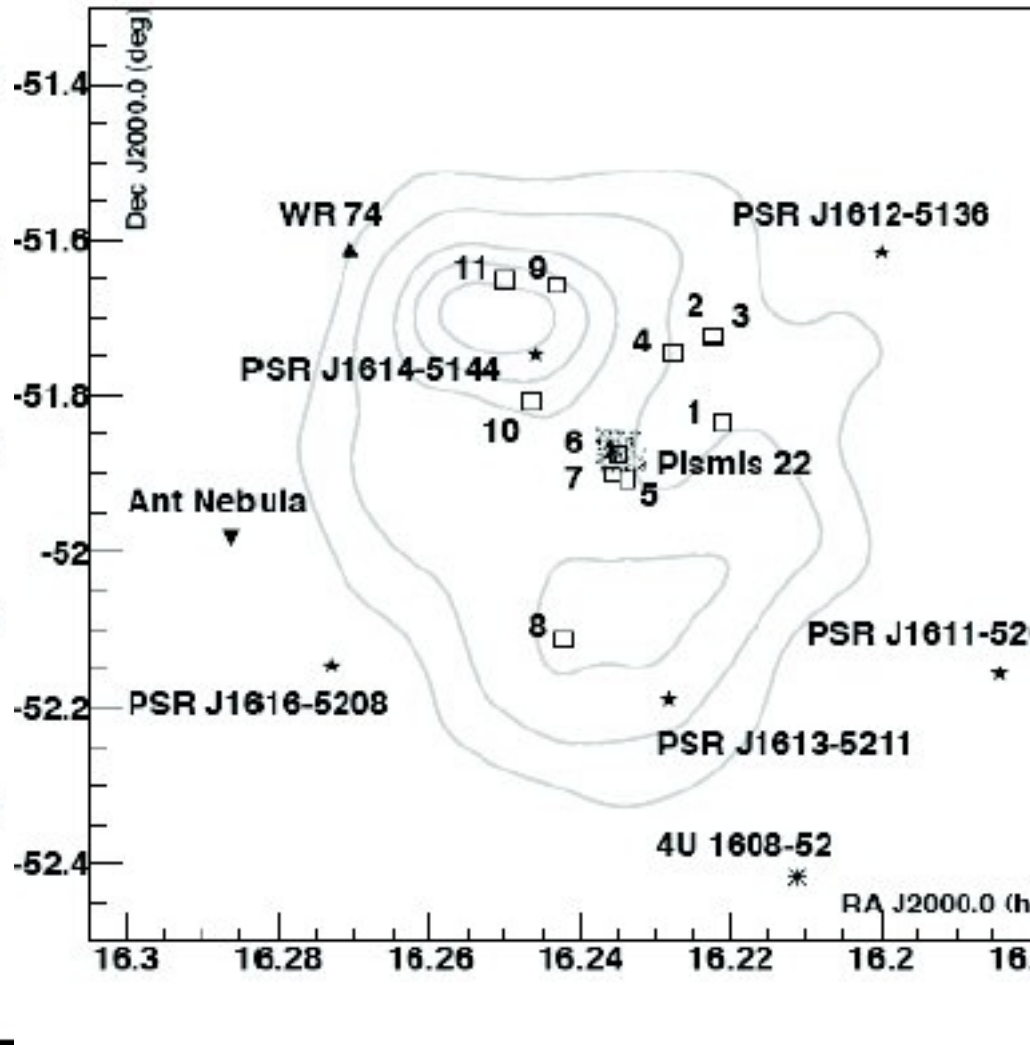
cf. E. de Ona-Wilhelmi, S. Ohm



γ - emission from young clusters ?

HESS J 1614-518 = Pismis 22 (?) (wind-blown bubble)

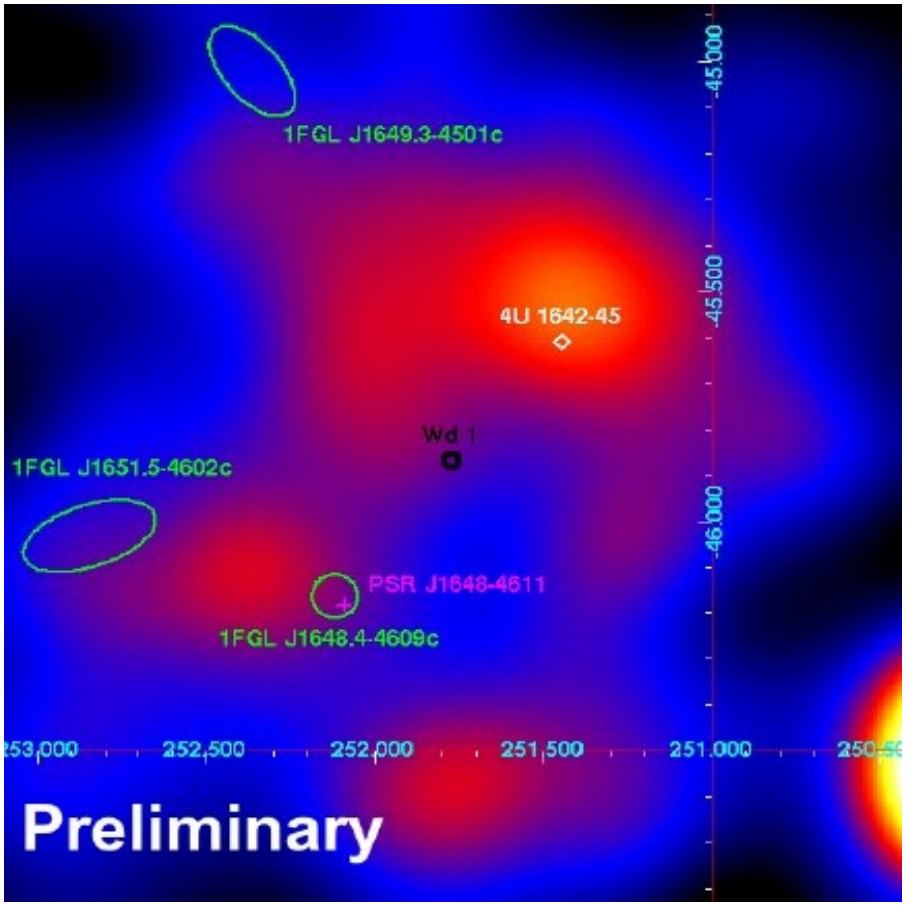




γ - emission from young clusters ?

Bright 'dark' source: Complex morphology, LMXB?, PWN?, Wd1?

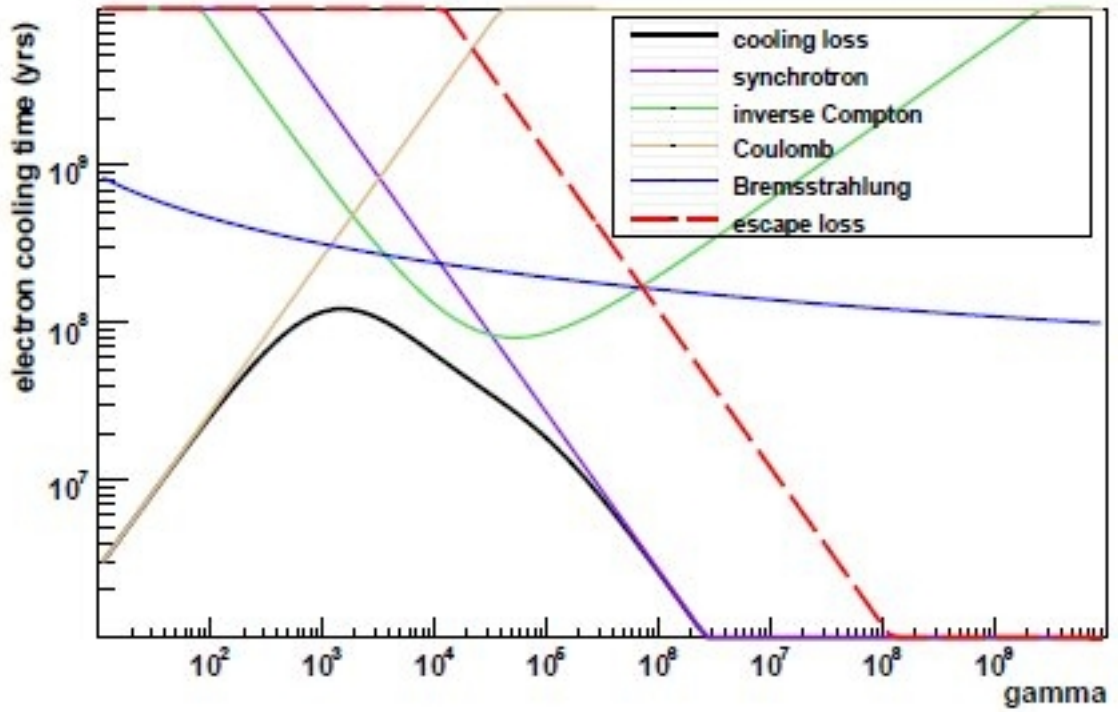
cf. M. Fernandes, E. de Ona-Wilhelmi (opt.image:ESO)



γ - emission from young clusters ?

Still an excellent candidate for a hadronic dark accelerator:

Electron cooling times (Manolakou et al., 2007) are too short to allow electrons to reach the entire source.



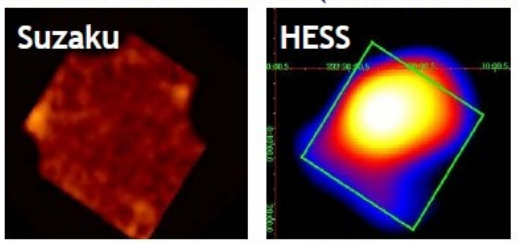
...while kinetic energy in wind-blown bubble is in the range of 7E52 (Crowther+, 06,07) to 4E53 (Starburst99, Leitherer 99) and can explain VHE via pp for 2-10% efficiency.

Dark VHE sources at GeV energies

All 'published' Galactic HESS sources have X-ray coverage with XMM, Suzaku, and/or Chandra (F_x/F_vhe mapped).

Several sources remain without plausible counterparts

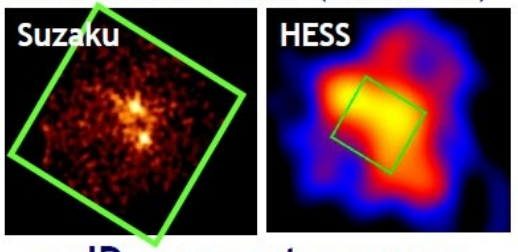
HESSJ 1616-508 (Matsumoto+07)



upper-limit !

$F_{TeV}/F_X > 55$

HESS J1804-216 (Bamba+07)



unID compact sources

$F_{TeV}/F_X > 13$

Many of them are LAT sources (all in previous collection)

Dark sources: MC associations?

HESS 1745-303:
Suzaku (2-8 keV)
and neutral iron maps
suggest association
of VHE to MC

As, possibly, in
CTB 37A, W28
and W51C (→)

(see also
Abdo et al. 09)

Fiasson+, ICRC '09